

FORM PTO-1390 (REV. 11-2000)		U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE		ATTORNEY'S DOCKET NUMBER 7170	
TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371				U.S. APPLICATION NO. (If known, see 37 CFR 1.5) 09/926225	
INTERNATIONAL APPLICATION NO. PCT/EP00/02639		INTERNATIONAL FILING DATE 27 March 2000		PRIORITY DATE CLAIMED 26 March 1999	
TITLE OF INVENTION DEVICE FOR PICTORIALY DEPICTING THREE-DIMENSIONAL OBJECTS					
APPLICANT(S) FOR DO/EO/US SETZER, STEFFEN et al.					
Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:					
<ol style="list-style-type: none"> 1. <input checked="" type="checkbox"/> This is a FIRST submission of items concerning a filing under 35 U.S.C. 371. 2. <input type="checkbox"/> This is a SECOND or SUBSEQUENT submission of items concerning a filing under 35 U.S.C. 371. 3. <input type="checkbox"/> This is an express request to begin national examination procedures (35 U.S.C. 371(f)). The submission must include items (5), (6), (9) and (21) indicated below. 4. <input checked="" type="checkbox"/> The US has been elected by the expiration of 19 months from the priority date (Article 31). 5. <input checked="" type="checkbox"/> A copy of the International Application as filed (35 U.S.C. 371(c)(2)) <ol style="list-style-type: none"> a. <input type="checkbox"/> is attached hereto (required only if not communicated by the International Bureau). b. <input type="checkbox"/> has been communicated by the International Bureau. c. <input type="checkbox"/> is not required, as the application was filed in the United States Receiving Office (RO/US). 6. <input checked="" type="checkbox"/> An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)). <ol style="list-style-type: none"> a. <input checked="" type="checkbox"/> is attached hereto. b. <input type="checkbox"/> has been previously submitted under 35 U.S.C. 154(d)(4). 7. <input type="checkbox"/> Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3)) <ol style="list-style-type: none"> a. <input type="checkbox"/> are attached hereto (required only if not communicated by the International Bureau). b. <input type="checkbox"/> have been communicated by the International Bureau. c. <input type="checkbox"/> have not been made; however, the time limit for making such amendments has NOT expired. d. <input type="checkbox"/> have not been made and will not be made. 8. <input type="checkbox"/> An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371 (c)(3)). 9. <input type="checkbox"/> An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)). 10. <input type="checkbox"/> An English language translation of the annexes of the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)). 					
Items 11 to 20 below concern document(s) or information included:					
<ol style="list-style-type: none"> 11. <input type="checkbox"/> An Information Disclosure Statement under 37 CFR 1.97 and 1.98. 12. <input type="checkbox"/> An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included. 13. <input checked="" type="checkbox"/> A FIRST preliminary amendment. 14. <input type="checkbox"/> A SECOND or SUBSEQUENT preliminary amendment. 15. <input type="checkbox"/> A substitute specification. 16. <input type="checkbox"/> A change of power of attorney and/or address letter. 17. <input type="checkbox"/> A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1.821 - 1.825. 18. <input type="checkbox"/> A second copy of the published international application under 35 U.S.C. 154(d)(4). 19. <input type="checkbox"/> A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4). 20. <input type="checkbox"/> Other items or information: 					

U.S. APPLICATION NO. (SEE 37 CFR 1.53) 097/926225		INTERNATIONAL APPLICATION NO. PCT/EP00/02639		ATTORNEY'S DOCKET NUMBER 7170	
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21. <input checked="" type="checkbox"/> The following fees are submitted: BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)): Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO..... \$1000.00 International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO \$860.00 International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO \$710.00 International preliminary examination fee (37 CFR 1.482) paid to USPTO but all claims did not satisfy provisions of PCT Article 33(1)-(4) \$690.00 International preliminary examination fee (37 CFR 1.482) paid to USPTO and all claims satisfied provisions of PCT Article 33(1)-(4) \$100.00 ENTER APPROPRIATE BASIC FEE AMOUNT =				CALCULATIONS PTO USE ONLY	
				\$ 1,040.00	
Surcharge of \$130.00 for furnishing the oath or declaration later than <input type="checkbox"/> 20 <input type="checkbox"/> 30 months from the earliest claimed priority date (37 CFR 1.492(e)).				\$	
CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE	\$	
Total claims	10 - 20 =		x \$18.00	\$	
Independent claims	1 - 3 =		x \$80.00	\$	
MULTIPLE DEPENDENT CLAIM(S) (if applicable)				+ \$270.00 \$	
TOTAL OF ABOVE CALCULATIONS =				\$ 1,040.00	
<input checked="" type="checkbox"/> Applicant claims small entity status. See 37 CFR 1.27. The fees indicated above are reduced by 1/2.				+	
SUBTOTAL =				\$ 520.00	
Processing fee of \$130.00 for furnishing the English translation later than <input type="checkbox"/> 20 <input type="checkbox"/> 30 months from the earliest claimed priority date (37 CFR 1.492(f)).				\$	
TOTAL NATIONAL FEE =				\$ 520.00	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). \$40.00 per property +				\$	
TOTAL FEES ENCLOSED =				\$ 520.00	
				Amount to be refunded:	\$
				charged:	\$

a. ☒ A check in the amount of \$ 520.00 to cover the above fees is enclosed.

b. ☐ Please charge my Deposit Account No. _____ in the amount of \$ _____ to cover the above fees. A duplicate copy of this sheet is enclosed.


c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 19-2105. A duplicate copy of this sheet is enclosed.

d. ☐ Fees are to be charged to a credit card. **WARNING:** Information on this form may become public. Credit card information should not be included on this form. Provide credit card information and authorization on PTO-2038.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137 (a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

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 SIGNATURE
 JOSEFINO P. DE LEON
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 33,166
 REGISTRATION NUMBER

Case 7170

PATENT COOPERATION TREATY
UNITED STATES DESIGNATED/ELECTED OFFICE
UNITED STATES PATENT AND TRADEMARK OFFICE

In re U.S. National Stage of : September 26, 2001
PCT Application No.: PCT/EP00/02639:
PCT Filing Date: 27 March 2000 :
Priority Date: 26 March 1999 :
Inventors: SETZER, Steffen et al. :
For: DEVICE FOR PICTORIALY :
DEPICTING THREE-DIMENSIONAL :
OBJECTS :

PRELIMINARY AMENDMENT

Honorable Commissioner of Patents and
and Trademarks
Box PCT
Washington, D.C. 20231

Dear Sir:

Please amend the above-identified application as follows:

IN THE CLAIMS:

Claim 6, line 1, please change "one of claims 1 to 5" to
-- claim 1 --.

Claim 10, line 1, please change "8 or 9" to -- 8 --.

REMARKS

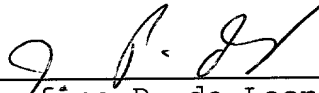
Applicants have amended the claims to remove multiple
dependencies.

PCT Application No.: PCT/EP00/02639

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It is respectfully requested that the amendment be entered before computing the filing fee.

Respectfully submitted,



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Device for pictorially depicting
three-dimensional objects

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The present invention relates to a device for pictorially depicting three-dimensional objects.

For the pictorial representation of three-dimensional objects and for the creation of a three-dimensional image data record, it is known in the art to measure the distance to the object which is to be depicted by means of generally at least two cameras and to create a "point cloud", i.e. a multitude of coordinate points with assigned image information which represent the surface of the object which is to be depicted. In a further step, the established points are linked to surfaces which topologically describe the surface of the object by means of a labourious calculation process. The result is a 3-D polygon data record of the depicted object.

A process is known from US-PS 5 818 959 for the creation of a three-dimensional image from at least two two-dimensional images, wherein a three-dimensional object is recorded by at least two cameras disposed horizontally about the object. During the recording, the three-dimensional object is irradiated with a striated pattern. The first of the recorded two-dimensional images is selected as a reference image, a further image is selected as a so-called second image. On the basis of these two

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images, taken from slightly-different locations, a three-dimensional image is calculated according to the so-called binocular principle, wherein the space in which the object is located is sub-divided into so-called voxels and the value of each voxel in each of the two two-dimensional images can be compared with one another. Identification of identical voxels is attained by means of the irradiated striated pattern. In order to minimise the required calculation input and to avoid the so-called background problem, cameras which are disposed further away are used to check the surface points of the object.

A process is known from US-PS 4 982 438 for recognition of the three-dimensional shape of an object, wherein the object which is to be recorded is surrounded by four pairs of cameras, especially disposed perpendicular to one another, disposed in a horizontal plane. The pairs of cameras each record a binocular image of the object. The three-dimensional shape of the object is calculated on the basis of these images in that the binocular calculation method is combined with the so-called Cone-Silhouetting Method.

25 A further process is known from EP 0 631 250 A2 for reproducing three-dimensional objects. With this process, a plurality of cameras are provided in different positions which are disposed so as to be moveable and/or which are suitable for recording a moved
30 object. In a similar manner to the processes described hereinbefore, a camera is selected as a reference camera and with regard to the image captured by this camera, corresponding points are sought

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in the images recorded by the other cameras which serve as a basis for the calculation of the voxel contents.

Processes are known from US-PS 4 825 393, US-PS 5 432 712, US-PS 5 577 130, US-PS 5 561 526 and US-PS 4 654 872 for the measurement of three-dimensional objects or for distance measurement, which are based on complex measurements derived from the binocular method.

10 The company Kaidan, Feasterville, Pennsylvania, USA,
offers a photographic device under the designation
Meridian C-60 which comprises a substantially C-shaped
rail, along the inside of which a camera is moveably
disposed. The object which is to be photographed is
15 placed on a rotating plate in such a way that the camera
which is moveable along the rail can be displaced about
the object in the vertical direction.

A system is known from "Illusion rundherum" by Bayer et al, c't, 1995, Volume 9, pages 104 to 107, in connection with the "QuickTime VR" system of the company Apple, wherein to attain a three-dimensional impression of an object which a user can fluidly move in all directions by using a mouse, objects are recorded all around using individual images with 360° horizontal and 180° vertical perspective with 10° spacing to one another.

With the known systems, it is disadvantageous that data processing systems require very high computing power as a result of the complex computing methods for creation of the three-dimensional polygon data records. A further disadvantage is the so-called background problem, since with the known systems, the objects which are to be depicted

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cannot be satisfactorily differentiated and demarcated from the image background.

On the basis of this, the object of the invention is to
5 provide a device for pictorial depiction of three-dimensional objects via which three-dimensional objects can be easily and cheaply depicted and reproduced for a viewer in perspective elevation for production of a
10 three-dimensional impression, using data processing systems with conventional computing performance. In particular, according to the invention it is to be possible to differentiate an object which is to be depicted from an image background without complex computing processes.

15 A device with the features of claim 1 is suggested in order to solve this object.

According to the invention, therefore, a number of
20 recordings are made from different directions of an object which is to be depicted by means of a plurality of cameras, and each of these recordings is stored with assigned relative coordinates camera/object. Therefore, in contrast to the prior art purely two-dimensional
25 information is stored, to which information relating to the spatial relationship between recording position and recorded object is assigned, instead of calculating a three-dimensional object data record from an abundance of recorded two-dimensional data. Reproduction of the
30 stored image data takes place via a suitable representation program in which the corresponding two-dimensional image which corresponds to the respective view is called up,

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dependent on the relative position of the object, i.e. reproduction of the stored image data takes place in perspective elevation for creation of a three-dimensional image by joining the two-dimensional image data with consideration for the associated coordinates. In this way, the impression is given that the object has been shown in a three-dimensional representation. In contrast to conventional three-dimensional applications, the device according to the invention requires substantially-less computing performance. As well as spatial and angular coordinates, the coordinates and parameters stored with the image data can also include time coordinates, which especially allows "dynamic" object depiction and corresponding representation in the case of changing, moving and also growing objects (plants).

The object which is to be depicted is turned and is recorded by means of cameras which are disposed in a spatially-defined manner. The associated angular position is assigned to each individual recording of the object, corresponding to the rotation of the object. In order to permit a perspective elevation of the object from various heights, the cameras are disposed at various heights in the space. A pre-determined number of recordings are made during a complete rotation of the object which is to be depicted. For example, during rotation of the object a recording is made every 10°, i.e. 36 recordings during a full rotation.

In an embodiment of the invention, the object which is to be depicted is recorded by means of two or more cameras, the relative positions of which are altered with regard to the object which is to be depicted. This alteration of the relative position is a rotation of the object which is to be depicted. Independent of the type of relative alteration of the

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position between the camera and the object which is to be depicted, it is important that the relative coordinates of each camera to the object which is to be depicted are known at all time points. The relative
5 coordinates are suitable spatial and/or angular coordinates.

In an advantageous embodiment of the invention, a plurality of cameras are arranged distributed spatially
10 around the object which is to be depicted. With a sufficiently-large number of cameras which can record the object from a sufficiently-large number of directions in order to guarantee a satisfactory perspective reproduction on the basis of two-dimensional
15 image data records, no relative alteration of the position between the cameras and the object which is to be depicted is necessary. However, if the number of cameras is not sufficiently large, the object which is to be depicted is rotated. For example, the cameras can
20 be disposed on a cylindrical or partially-spherical (dome-like) surface which substantially symmetrically surrounds the object.

In an especially advantageous embodiment of the
25 invention, a plurality of cameras are arranged distributed around the object, in a plane which extends through the object which is to be depicted. Here, it is preferred that the arrangement of cameras takes place along a substantially C-shaped or partially-circular
30 rail. The object which is to be depicted is, for example, disposed approximately in the centre of the curvature of the rail. In order to create a relative position alteration, the object is either rotated or the rail, together with the camera disposed thereon, is
35 swivelled around the object, for example along a rail which extends around the object.

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In a further embodiment of the invention, the device according to the invention has a background surface with disposed approximately centrally in the curvature of the rail. In order to produce a relative position alteration, the object is either rotated or the rail, together with the camera disposed thereon, is swivelled around the object, for example along a rail which extends around the object.

In a further embodiment of the invention, for which independent protection is also sought, according to claim 16 the device according to the invention has a background surface with substantially constant colour tone in the colour space. A simple, clear and unambiguous demarcation of the object from the background is guaranteed with such a background surface which is configured so that it represents the entire image background of the recorded object in each image taken by the at least one camera.

In an embodiment of the invention, illumination means are provided to illuminate the rear side of the background which is remote from the camera. However, illumination of the background surface can also take place in a suitable manner from the side or from the front.

In another embodiment of the invention, the background surface itself is configured to be luminous, and is preferably configured as an electro-luminescing film. This also provides good demarcation results.

In order to improve still further the demarcation between the object and the background, in a further embodiment of the invention a

laminar or film-shaped filter is provided which covers the background surface.

Other advantages and embodiments of the invention result
5 from the description and the accompanying drawings.

It is understood that the hereinbefore-named and subsequently-described features cannot only be used in the combination stated here, but also in other
10 combinations or on their own without leaving the framework of the present invention.

The invention is described in the drawings with reference to embodiment examples, and is explained in
15 greater detail in the following text with reference to the drawings.

Figure 1 shows a perspective schematic elevation of a first embodiment of a device according to the invention for pictorially depicting three-dimensional
20 objects.

Figure 2 shows the device of Figure 1 in top elevation.

Figure 3 shows a schematic perspective representation of a second embodiment example of a device according to the invention with a plurality of cameras disposed along a substantially partially circular rail and of an object which is to be depicted disposed on a rotating
30 plate.

Figure 4 shows the device of Figure 3 in another elevation.

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5 tensioned polygon jacket surface formed by the background surface 18 and are inserted or worked into the background surface 18. In this way, the cameras 12 are each disposed at the same distance from the rotational axis of the jacket surface and the rotational axis of the rotating plate 16, which is substantially coincidental therewith.

10 Second cameras, provided with the reference character 13, are disposed in the interior of the volume formed by the background surface 18, partially or directly above the rotating plate 16.

15 When recording an object 14, at least one image is taken by each of the cameras 12, 13 which is stored together with the relative coordinates of the associated camera relative to the object 14 as a two-dimensional image data record in a storage apparatus which is not represented in greater detail. The coordinates are
20 preferably spatial and/or angular coordinates which permit calculation of the distance between the respective camera and the object and the angle between the camera and the object (with regard to the horizontal or the vertical axis, or another reference axis).

25 If the number of cameras 12, 13 which are distributed in the room around the object 14 is insufficient to produce a satisfactory perspective elevation of the object which is to be depicted, for example because a substantial
30 portion of the object 14 could not be photographed, the object 14 is rotated during recording by means of a suitable rotation means (in the illustrated example, a rotating plate 16). This rotation of the object 14, which occurs slowly, allows images to be captured and
35 stored by each of the cameras 12, 13 disposed around the object 14

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at pre-determined angular intervals, which, with consideration of the coordinates which are stored together with the images into which the respective angular position of the object flows, allows
5 reproduction of the depicted object in perspective elevation for creation of a three-dimensional impression.

Figure 3 shows, as a preferred embodiment of the
10 invention, a device 20 for pictorially depicting three-dimensional objects. The device 20 comprises a substantially partially circular camera arm 22, in which a plurality of cameras are arranged. The camera arm 22 is disposed upright, i.e. the plane in which the camera
15 arm 22 lies extends substantially perpendicular to the horizontal, or the ground surface. In the following text, the camera arm 22 is designated as rail 22 for reasons of simplicity.

20 The cameras 24 are disposed on the rail 22 in such a way that their optical axes extend in each case substantially in the plane of the rail 22 and are substantially aligned on the central point of the partial circle of the rail 22. In other words, the
25 cameras 24 are disposed along the rail with a substantially radial beam path.

The device 20 also comprises as a rotating apparatus a
rotating plate 25 on which an object 28 which is to be
30 depicted is disposed. The rotational axis of the rotating plate 26 is here substantially in the plane of the rail 22 and the plane in which the optical axes of the cameras 24 lie extends through the object 28.

Furthermore, the device 20 comprises a first background surface 30 and a second background surface 31. The first background surface 30 is laid out below the rail 22 and the rotating plate 26 along the ground surface, whilst the second background surface 31 is arranged substantially perpendicular to side of the rotating plate 26 which is remote from the rail 22. The background surfaces 30, 31 are disposed so that they represent the entire background in the images captured by the cameras 24.

Since the rotating plate generally lies in the image surface of every camera, it is an important part of the background and is thus preferably adapted to the background surface for reasons of standardisation, in that at least the surfaces and edges of the rotating plate which appear in the camera image are covered or coated with the same material as the background surface.

Furthermore, the device 20 has illuminating members 32 for illuminating the object 28. The illuminating members 32 are disposed near the cameras 24 in such a way that dazzle-free illumination of the object 28 is possible. The illuminating members 32 are, for example, attached to the side edges of the rail 22 by means of arms, not illustrated in greater detail, so that individual dazzle-free adjustment of the illumination is possible.

According to the invention, the background surfaces 30, 31 are advantageously configured with a substantially constant colour location in the colour space. In an especially advantageous embodiment of the invention the background surfaces are configured to be self-illuminating, for example as electro-luminescing film.

In order to attain especially good constance of the colour location, the background surfaces are covered with filters, not illustrated in the Figures in greater detail. In the case of a self-illuminating
5 configuration of the background surfaces, it is possible under certain circumstances to dispense with the additional illuminating members 32.

Figure 4 shows the device of Figure 3, according to the
10 invention, from another perspective.

Figure 5 shows the device 20 of Figure 3, wherein an object 29 which is to be depicted is hung via a hanging apparatus 34. Hanging the object which is to be
15 depicted has the advantage that the underside of the object can be at least partially depicted and recorded by the cameras disposed in the lower area of the rail 22.

20 The hanging apparatus 34 is especially a torsion-free connection, attached to the rotating disc 26, between the rotating plate 26, the object 29 and the upper end 22b of the rail 22.

25 Therefore according to the invention, two-dimensional images of an object which is to be depicted are captured and stored with the relative camera coordinates as additional parameters. With the help of a suitable representation program, the image which corresponds to
30 the respective view is called up dependent on the relative position of the viewer to the object. This gives the impression that the object is observed in a three-dimensional representation. In contrast with conventional

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Claims

1. A device for pictorially depicting three-dimensional objects with a plurality of cameras (12, 13; 24) which are arranged distributed in defined spatial arrangement about an object (14; 28, 29) which is to be depicted, and a storage and reproduction apparatus, wherein recording of the object (14; 28, 29) which is to be depicted takes place from a plurality of recording devices of the plurality of cameras (12, 13; 24) relative to the object (14; 28, 29) by rotating the object via a rotating apparatus (16; 26), storage of two-dimensional image data of each recording apparatus takes place in the storage apparatus together with associated coordinates of the at least one camera (12, 13; 24) with regard to the object (14; 28, 29) which is to be depicted, and reproduction takes place of the stored image data in perspective elevation by generation of a three-dimensional impression by joining the two-dimensional image data with consideration for the associated coordinates.
2. A device according to claim 1, wherein the cameras are arranged on a cylindrical or partially-spherical surface surrounding the object (14) which is to be depicted.
3. A device according to claim 1, wherein means (16; 26, 34) for alteration of the relative position of the plurality of cameras (12, 13; 24) with regard to the object (14; 28, 29) which is to be depicted and means for detecting the relative

5 4. A device according to claim 3, wherein the plurality of cameras (24) are arranged distributed about the object (28, 29) in a plane extending through the object which is to be depicted.

15 6. A device according to one of claims 1 to 5, with at
least one camera (12, 13; 24) which can be aligned
on an object (14; 28, 29) which is to be depicted
for recording the object which is to be depicted
and with a background surface (18; 30, 31) with
20 substantially constant colour location in colour
space.

8. A device according to claim 6, wherein the background surface (18; 30, 31) is self-illuminating.

10. A device according to claim 8 or 9, wherein a laminar or film-shaped filter is provided which covers the background surface (18; 30, 31)

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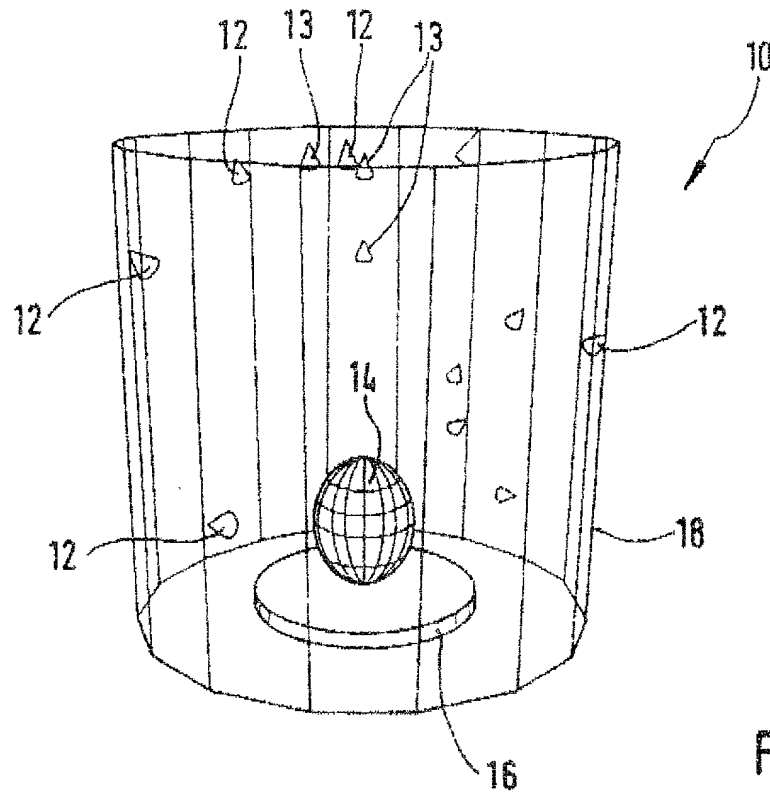


Fig. 1

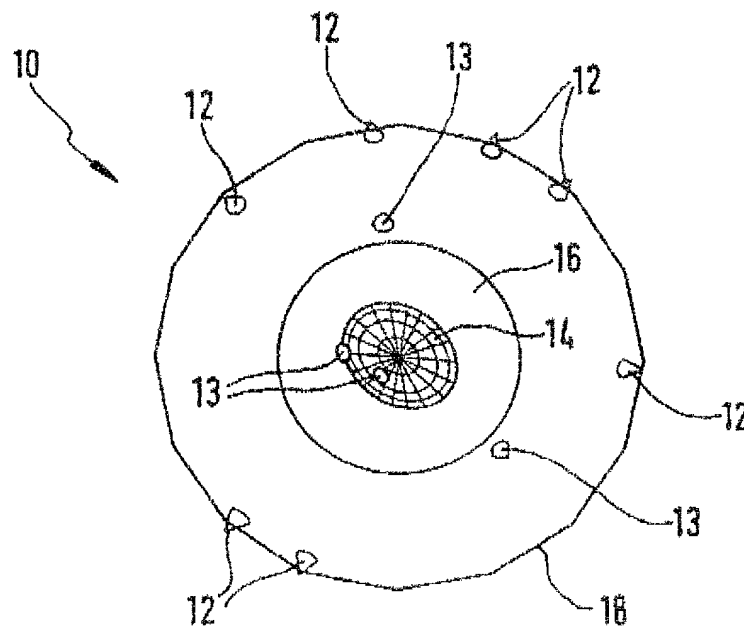


Fig. 2

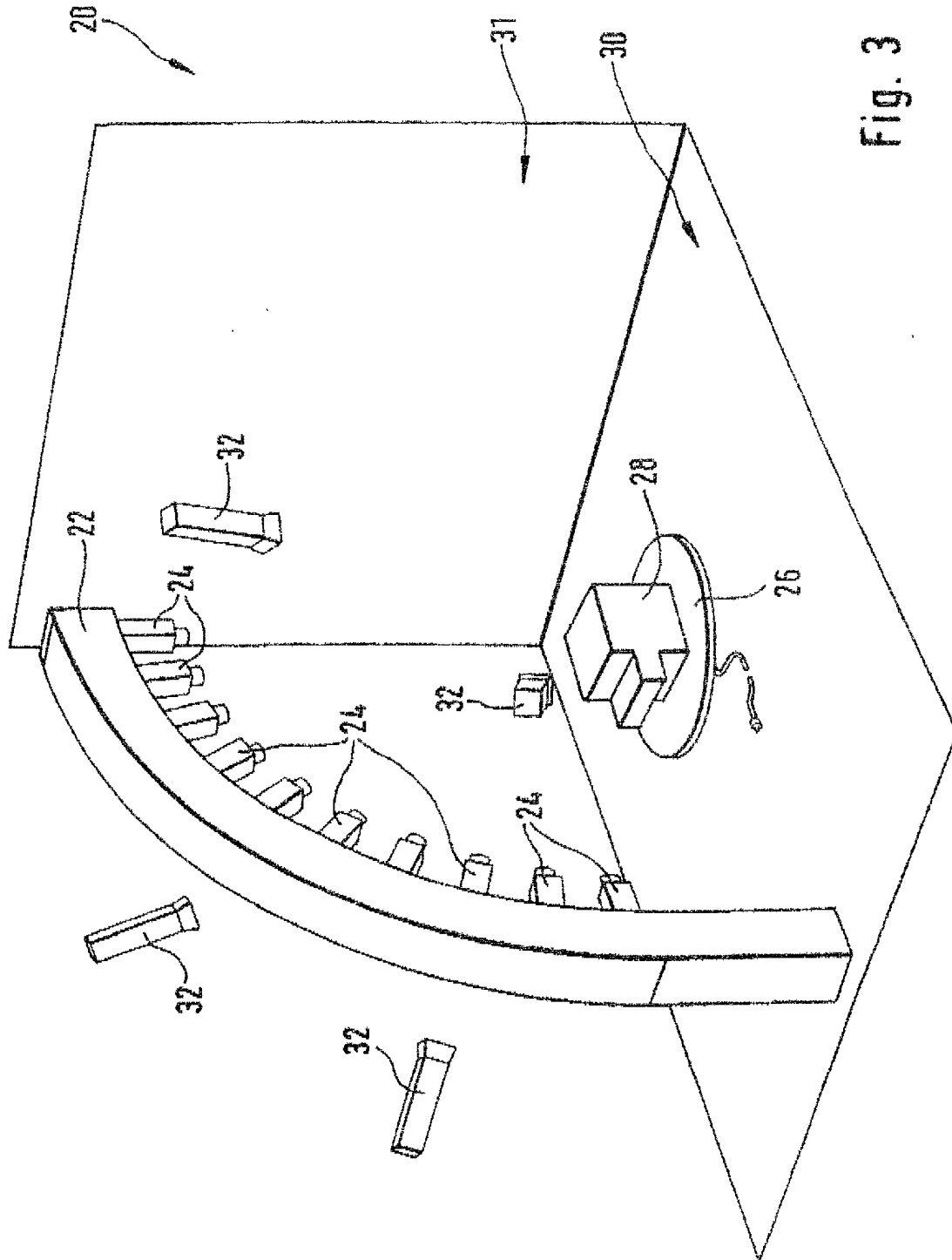
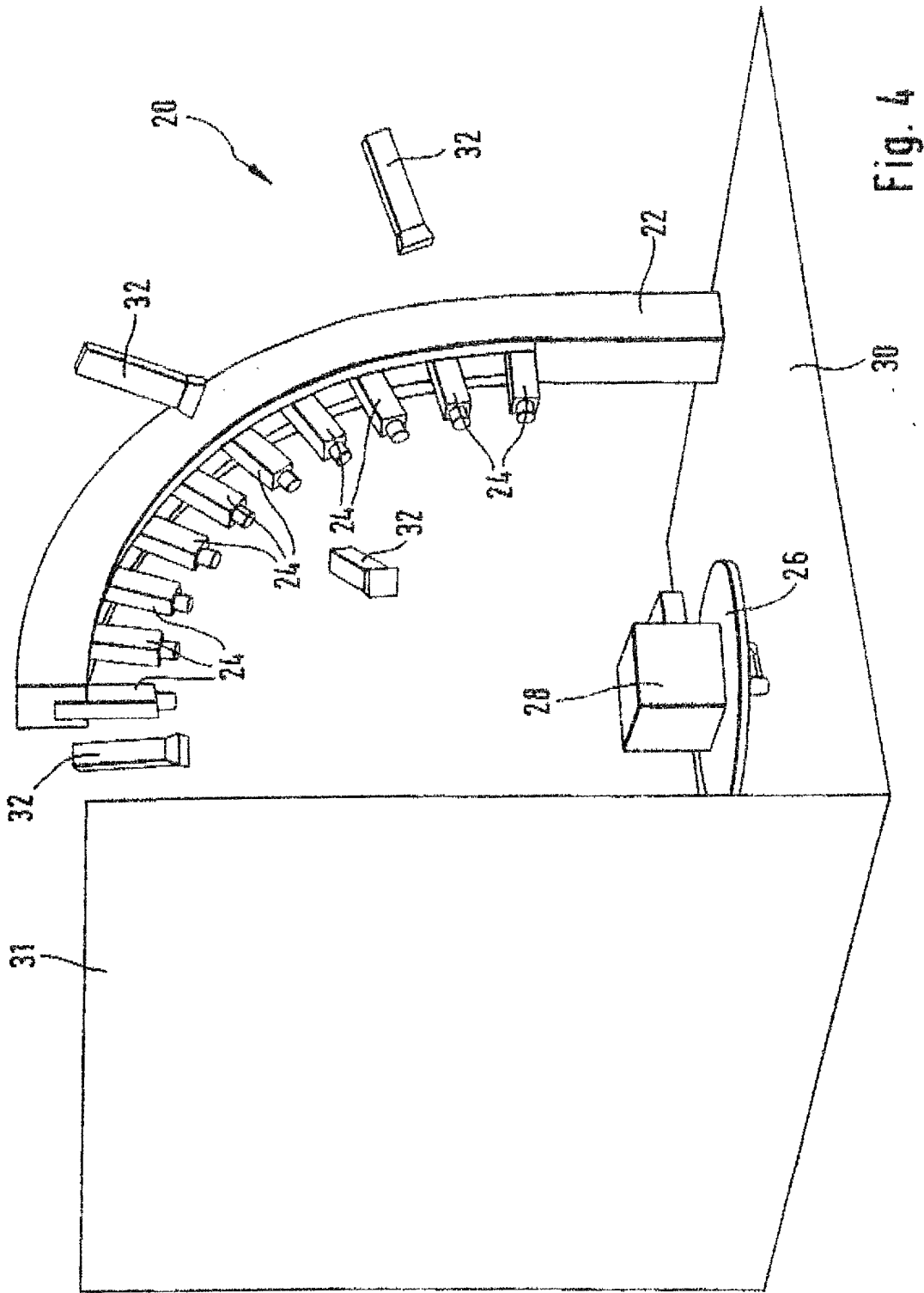
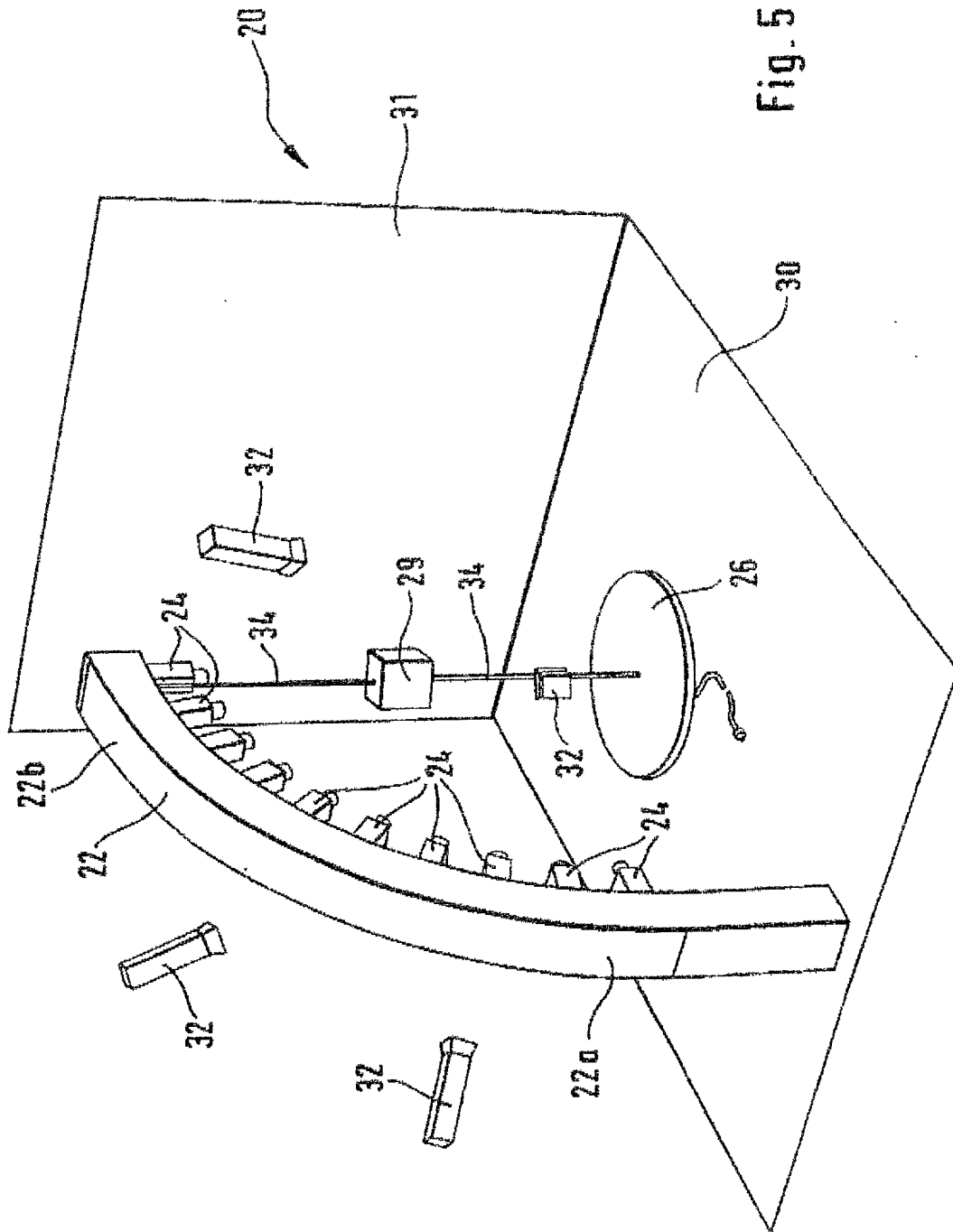


Fig. 3





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